Connected Particles

1 Two particles P and Q of masses 8 kg and 2 kg respectively, are connected by a light inextensible string. The particles are on a smooth horizontal plane. A horizontal force of magnitude F is applied to P in a direction away from Q and when the string is taut the particles move with acceleration $0.4\,\text{m s}^{-2}$..

a Find the value of F.

b Find the tension in the string.

c Explain how the modelling assumptions that the string is light and inextensible are used.

Hint For part **b** consider P on its own.

2 Two particles P and Q of masses 20 kg and m kg are connected by a light inextensible rod. The particles lie on a smooth horizontal plane. A horizontal force of 60 N is applied to Q in a direction towards P, causing the particles to move with acceleration $2\,\text{m s}^{-2}$.

a Find the mass, m, of Q.

b Find the thrust in the rod

3 Two particles P and Q of masses 7 kg and 8 kg are connected by a light inextensible string. The particles are on a smooth horizontal plane. A horizontal force of 30 N is applied to Q in a direction away from P. When the string is taut the particles move with acceleration, $a\,\text{m s}^{-2}$.

a Find the acceleration, a, of the system.

b Find the tension in the string.

4 Two boxes A and B of masses 110 kg and 190 kg sit on the floor of a lift of mass 1700 kg. Box A rests on top of box B. The lift is supported by a light inextensible cable and is descending with constant acceleration $1.8\,\text{m s}^{-2}$.

a Find the tension in the cable.

b Find the force exerted by box B

i on box A **ii** on the floor of the lift.

(P) **5** A lorry of mass m kg is towing a trailer of mass $3m$ kg along a straight horizontal road. The lorry and trailer are connected by a light inextensible tow-bar. The lorry exerts a driving force of 50 000 N causing the lorry and trailer to accelerate at $5\,\text{m s}^{-2}$. The lorry and trailer experience resistances of 4000 N and 10 000 N respectively.

a Find the mass of the lorry and hence the mass of the trailer.

b Find the tension in the tow-bar.

c Explain how the modelling assumptions that the tow-bar is light and inextensible affect your calculations.

(E) **6** Two particles A and B of masses 10 kg and 5 kg respectively are connected by a light inextensible string. Particle B hangs directly below particle A. A force of 180 N is applied vertically upwards causing the particles to accelerate.

a Find the magnitude of the acceleration. **(3 marks)**

b Find the tension in the string. **(2 marks)**

(E/P) **7** Two particles A and B of masses 6 kg and m kg respectively are connected by a light inextensible string. Particle B hangs directly below particle A. A force of 118 N is applied vertically upwards causing the particles to accelerate at $2\,\text{m s}^{-2}$.

a Find the mass, m, of particle B. **(3 marks)**

b Find the tension in the string. **(2 marks)**

E/P **8** A train engine of mass 6400 kg is pulling a carriage of mass 1600 kg along a straight horizontal railway track. The engine is connected to the carriage by a coupling which is parallel to the direction of motion of the train and carriage. The coupling is modelled as a light rod. The engine provides a constant driving force of 12 000 N. The resistances to the motion of the engine and the carriage are modelled as constant forces of magnitude R N and 2000 N respectively.

Given that the acceleration of the engine and the carriage is 0.5 m s^{-2}:

a find the value of R **(3 marks)**

b show that the tension in the coupling is 2800 N. **(2 marks)**

E **9** A car of mass 900 kg pulls a trailer of mass 300 kg along a straight horizontal road using a light tow-bar which is parallel to the road. The horizontal resistances to motion of the car and the trailer have magnitudes 200 N and 100 N respectively. The engine of the car produces a constant horizontal driving force on the car of magnitude 1200 N.

a Show that the acceleration of the car and trailer is 0.75 m s^{-2}. **(2 marks)**

b Find the magnitude of the tension in the tow-bar. **(3 marks)**

The car is moving along the road when the driver sees a set of traffic lights have turned red. He reduces the force produced by the engine to zero and applies the brakes. The brakes produce a force on the car of magnitude F newtons and the car and trailer decelerate.

c Given that the resistances to motion are unchanged and the magnitude of the thrust in the towbar is 100 N, find the value of F. **(7 marks)**